A list of the fishes known to occur in the Arctic Ocean, north of Behring's Straits, by Tarleton H. Bean, is appended. The list is based exclusively upon specimens in the United States National Museum, and is acknowledged to be incomplete; it only contains twenty-one species, eight others being added as "properly belonging to the fauna." No details beyond the localities where found are given.

SOUND-MILLS

AFTER the notable researches of Crookes on radiation, which culminated in the discovery of the radiometer, or light-mill, it was a natural transition of thought which suggested to several minds almost simultaneously the possibility of devising an apparatus which should rotate under the influence of sound-waves as does the radiometer under the influence of the rays of light and heat. Such instruments were indeed devised independently about six years ago by Lord Rayleigh, by Prof. Alfred M. Mayer of Hoboken, by Mr. Edison, the well-known inventor, by Prof. Mach of Prague, by Dr. A. Haberditzel of Vienna, and by Prof. V. Dvorák of the University of Agram (in Croatia). These researches, though of great scientific interest, have been somewhat overlooked in the rush of scientific inventions during the intervening years. During the course of the past year, however, Dr. Dvorák has given to the world, in the pages of the *Zeitschrift der Instrumentenkunde* (vol. iii. Heft 4), a detailed account of his experiments, together with figures of various pieces of apparatus hitherto undescribed. We propose to give a *résumé* of the principal points of Dvorák's researches.

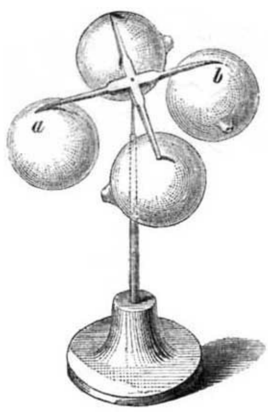

Fig. 1.

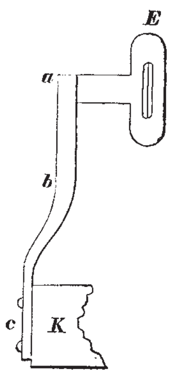

Fig 2.

Four kinds of sound-mills are described by Dvorák, two of them depending on the repulsion of resonant-boxes or cases, and two others on different principles.

The first of these instruments is depicted in Fig. 1, and consists of a light wooden cross, balanced on a needle point, carrying four light resonators made of glass. These resonators are hollow balls of 4·4 cms. diameter, with an opening of 0·4 cm. at one side. They respond to the note g' (= 392 vibrations). When the note g' is forcibly sounded by an appropriate tuning-fork, the air in each of the resonators vibrates in response, and the apparatus begins to rotate. As a resonator will respond when placed in any position with respect to the source of sound, it is clear that one single resonator properly balanced should rotate; and this is found to be the case, though, naturally, the action is more certain with four resonators than with one.

Before proceeding to the other forms of sound-mill devised by Dvorák, it may be well to explain briefly the cause of the phenomenon, and to describe Dvorák's particular method of exciting the appropriate sound Dvorák has pointed out, as indeed has been done elsewhere both by Lord Rayleigh and by Prof. A. M. Mayer, that, when sounds of great intensity are produced, the calculations which are usually only carried to the first order of approximation cease to be adequate, because now the amplitude of motion of the particles in the sound-wave is not infinitely small as compared with the lengths of the sound-waves themselves. Mathematical analysis shows that under these circumstances the mean of the pressures in the condensed part and in the rarefied part of the sound-wave is no longer equal to the undisturbed atmospheric pressure, but is always greater. Consequently at all nodal points in the vibrations of the air in tubes or resonant-boxes the pressure of the air is greater than elsewhere; and therefore any resonator closed at one side and open at the other is urged along bodily by the slight internal excess of pressure on the closed end. The apparatus, Fig. 1, therefore rotates by reaction, in the same way as Hero's primitive steam-engine rotated, though the reaction is due to a different cause.

To produce vibrations of sufficient intensity Dr. Dvorák employs heavy tuning-forks mounted on resonant-cases, and excited electrically. For this purpose he places between the prongs of the fork an electromagnet constructed on the following plan. Two plates of iron separated by a sheet of paper are used as a core. They

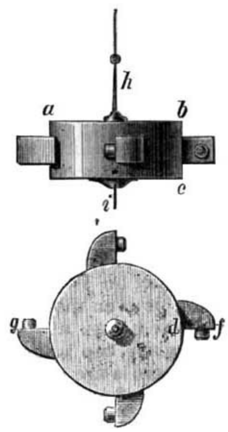

Fig. 3.

are cut of such a breadth as to lie between the prongs without touching them. This core is overwound with insulated copper wire, as shown at E, Fig. 2, and the electromagnet is then mounted by a bent piece of wood, *abc*, upon the sounding-box, K, of the fork. The wires are connected in a circuit with a battery, and with the electromagnet of a self-exciting tuning-fork of the same note. Dr. Dvorák is extremely particular about the arrangements of the resonant-boxes of his tuning-forks. They must not touch the table, the arm *a b c* being clipped at about the point *b* in a firm support. Moreover the resonant-boxes themselves require to be specially tuned, for all are not equally good. Dr. Dvorák points out that, beside the tone of the fork, and the tone of the air column in the cavity of the box, there is also a tone proper to the wood of the box itself, which in most of the forks used in acoustic researches is too base, the wooden walls being too thin. To hear this tone the prongs of the fork should be damped by sticking a cork between them, and the cavity should be filled with cotton-wool, while the wooden box is gently struck with the knuckle or with a cork hammer. It is important that the wood-tone should be tuned up to coincidence with the tone of the fork and with that of the air in the cavity. Dr. Dvorák himself used the box depicted further on in Fig. 6, in which drawing F is the socket into which the stem of the fork

was screwed. The wood was tuned by planing it away at the top and bottom, while the air cavity was tuned by enlarging the circular opening in front. In the later researches the box stood on four feet made of india-rubber tubing. The note of the fork so mounted was very strong. At 40 cms. distance it would set the sound-mill in motion.

Dvorák's second apparatus, a "rotating resonator," consists of a short cylindrical box, constructed of stiff glazed paper, having four projections, shown in plan and elevation in Fig. 3, each of which bears at its side a short open tube of paper. It is, in fact, a resonator with four openings, arranged so that it can be hung upon a silk fibre. A fine needle projects also below to steady the

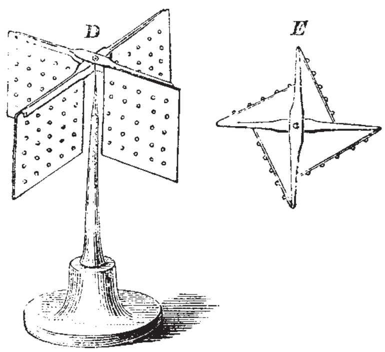

FIG. 4

motion during its rotation, which occurs whenever the apparatus is brought near to the sounding-fork. For the note g' the dimensions were: diameter, 7 cms.; height, 3·6 cms.; diameter of openings, 0·6 cm.

The third apparatus is the "sound-radiometer" described by Dvorák before the Imperial Viennese Academy in 1881. Its cause of action is less readily explained, though its construction is even more simple. Its form is shown in Fig. 4, D; there being, as before, a light cross of wood, pivoted by a glass cap upon a vertical needle. To the four arms of the cross are cemented four pieces of fine white card, about 0·08 cm. thick, perforated with holes which are depressed conically at one side, and raised at the other. These holes may be made by punch-

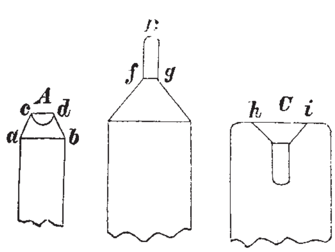

FIG. 5.

ing the card upon a lead block with a steel perforating-punch of the form shown in Fig. 5, A, the dimensions of which are: $ab = 0·38$ cm.; $cd = 0·2$ cm. The holes should be from 0·6 to 0·65 cm. apart from one another. When a card so perforated is held in front of the opening of the resonant-box of the tuning-fork it is repelled if the smaller ends of the conical holes are toward the box; or is attracted if the wider openings are toward the box. A better, but less simple, way of perforating the cards is by the use of the conical steel punch shown in Fig. 5, B, and the matrix, Fig. 5, C. The angle of the cone is 55°, and the narrow projecting nose of steel is 0·2 cm. The card should be damped, laid on the matrix C, and the hole pierced by two or three blows upon the die. Dr. Dvorák prefers this plan: it throws up a high burr or edge behind the conical hole, and such perforations are more effective. The cards may be varnished, and are then mounted upon the cross. The rotations are more rapid if the cards are set on obliquely in the fashion shown in Fig. 4, E, the burred sides being outwards. Cards with twenty-five perforations so mounted rotate briskly when the "mill" is set in front of the resonant-box.

The fourth apparatus of Dvorák is called by him an "acoustic anemometer." It is shown in Fig. 6. This is merely a little "mill" of simple construction, the vanes being small pieces of stiff paper or card slightly curved. The sounding-box previously described is placed a little way from it, and between them is held an ordinary Helmholtz's resonator, with its wide mouth, *b*, turned toward the box, and its narrow opening, *a*, toward the mill. From what has been previously said it will be understood that the internal increase of pressure in the resonator at *a* has the effect of driving a jet of air gently against the sails of the mill, which consequently rotates. Dr. Dvorák also suggests that this two-aperture resonator may be replaced by one having but one aperture, as shown at R, with its

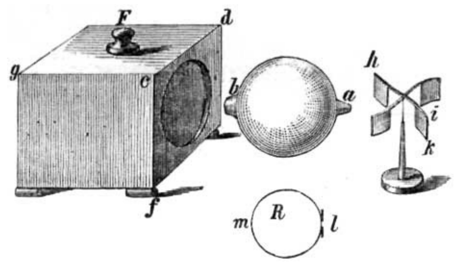

FIG. 6.

open side, *l*, turned towards the mill. This resonator is formed of a glass ball cut away at one side and cemented to a glass plate having a small hole at the centre. It may be remarked that when the air ejected from the mouth of this resonator is examined by the method of mixing smoke with it, and then viewing it through slits cut in a rotating disk, the currents are seen to consist of a series of vortex-rings.

A second kind of "acoustic anemometer" may be made by taking a card pierced with 100 conical holes, as previously described, and placing this between the resonant-box and the "mill." The latter rotates in the wind which passes through the conical holes.

Space does not admit of a comparison being drawn between these instruments and those of Mayer, Mach, and others, which are very closely akin in their design and mode of action, interesting though such a comparison might be. Nor can we here compare the action of these instruments with the "phonomotor" with which Mr. Edison literally accomplished the feat of talking a hole through a deal board. But this remarkable machine was a purely mechanical toy, which converted the vibrations of the voice, by means of a very finely-cut ratchet-wheel, into a motion of rotation round an axis.

SILVANUS P. THOMPSON

NOTES

IN the last week British science has sustained a great loss in the death of Mr. Thomas Chenery, the editor of the *Times*. During his all too short reign the leading journal of Europe has been in strict harmony with the real progress of humanity, instead of being merely a chronicle of "politics" and "society," and day by day it has been wonderful to watch with what continuous well-balanced vigour and skill the general public has been made interested in the victories achieved in the domains of science, literature, and art, as only a daily journal can interest it.